Impact of the ENSO Snowpack on the Western United States: A Global Climate Model Study

Jiming Jin and Norman L. Miller
Contact: Jiming Jin, 510/486-7551, jimingjin@lbl.gov

RESEARCH OBJECTIVE

Snowpack is a major water resource in the western U.S.. An accurate forecast of snow amount is essential to water allocation in this region. The objectives of this study are to examine the relationship between El Niño Southern Oscillation (ENSO) and snowpack over this region and to investigate—by comparing observations to simulations from a state-of-the-art global climate model (GCM)—how ENSO affects snow accumulations.

APPROACH

The GCM used in this study is the Community Climate Model Version 3 (CCM3) developed by the National Center for Atmospheric Research (Kiehl et al., 1996). To accurately represent the snowpack in the model, a Snow-Atmosphere-Soil Transfer (Jin et al., 1999) land-surface model with sophisticated snowpack processes was coupled to CCM3. A 45.5-year simulation from December 1949 to May 1995 was generated from this coupled model, which was forced by observed global sea surface temperature (SST) data with year-to-year variations. The observed Snow Water Equivalent (SWE) depths were collected from more than 300 snow-course locations in the western U.S.

ACCOMPLISHMENTS

Figure 1 illustrates the correlation between observed Niño-3.4 SSTs averaged over 120°W–170°W and 5°S–5°N, and SWEs from the model output and observations during winter and early spring for 1950 to 1994. This figure indicates that significant correlations occur in the western U.S. for both simulations and observations, suggesting that ENSO is an important factor causing snow anomalies. Analysis indicates that in the Northwest, the observed anomalous snow patterns are caused by the winter precipitation variability associated with the ENSO, whereas the simulated snow anomalies result from the temperature variations caused by the climate shift. In the Southwest, the simulated positive snowpack anomalies that result from the stronger precipitation are associated with the warm phase of the ENSO, which is consistent with the observed processes. However, the negative snow anomalies for both simulations and observations appear to have no connections with the tropical Pacific SSTs, which are attributed to the weakened precipitation caused by atmospheric internal variability.

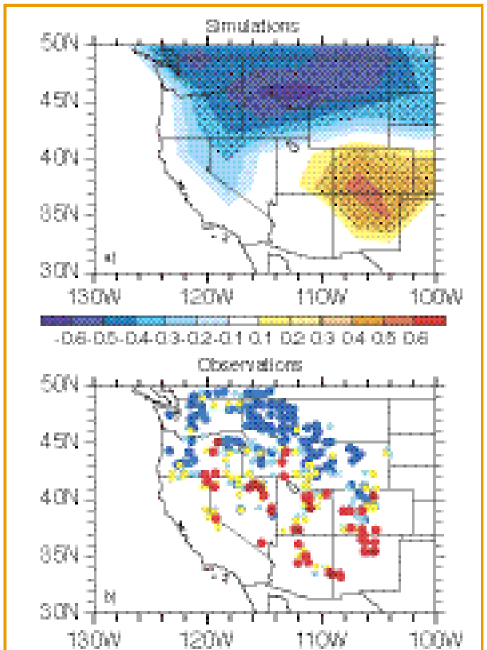

Figure 1. Correlation coefficients between Niño-3.4 and (a) SWEs from the CCM3 output and (b) observed snowcourse data in the western U.S. Values in stippled areas pass the 95% significance Student's *t* test.

SIGNIFICANCE OF FINDINGS

This study clarifies how the ENSO affects snowpack in the western U.S. and improves our understanding of the mechanism of snow anomalies. The modeled atmosphere in the mid-latitudes incorrectly responds to the tropical Pacific SSTs and shifts the way the air mass gets transported over the Northwest (compared to observations). These findings will greatly benefit climate and water- resources forecasts and future model development.

RELATED PUBLICATIONS

Jin, J., X. Gao, Z. Yang, R.C. Bales, S. Sorooshian, R.E. Dickinson, S. Sun, and G. Wu, One-dimensional snow water and energy balance model for vegetated surfaces. Hydrological Processes, 13, 2467–2482, 1999.

Jin, J., N.L. Miller, S. Sorooshian, and X. Gao, 2003: Impact of ENSO snowpack in the western U.S.: A GCM Study. Presented at the American Meteorological Society Conference, Long Beach, California, Feb. 2003; Journal of Climate, 2003 (manuscript in final preparation).

Kiehl, J.T., J.J. Hack, G.B. Bonan, B.A. Boville, B.P. Briegleb, D.L. Williamson, and P.J. Rasch, Description of the NCAR Community Climate Model (CCM3). NCAR Tech. Note, NCAR/TN-420+STR [Available from the National Center for Atmospheric Research, Boulder, Colorado], 1996.

ACKNOWLEDGMENTS

Support was provided by the NASA Regional Earth Science Applications Center Program under Grant No. NS-2791.